

High-Pressure Injection Injuries to the Hand: A Case Report

High-pressure air injection injuries

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Abstract

High-pressure injection (HPI) injuries to the upper extremity is a rare but very serious clinical condition. These injuries, which initially seem harmless at first due to a small puncture entry wound, cause serious damage to most internal structures of the fingers and hands due to the large penetration of the injected substance. In addition, high-pressure pneumatic tool injuries are a wellknown cause of HPI. Minor wounds in the web space of the hand may result in a transport of air across the defect, acting like a check-valve mechanism to trap and then force the air into the subcutaneous tissue, as illustrated by of our patient. The clinical effects of the HPI injury depend upon a number of variables including the pressures involved, chemical toxicity, the quantity of material injected. Evidence within the literature has shown that delay in identifying and treating such injuries can lead to devastating consequences. The purpose of this case report is to describe a patient with the subcutaneous emphysema and compartment syndrome that developed secondary to pressure balloon machine blowing accident.

Keywords

Subcutaneous Emphysema; High-Pressure Gas Injection; Compartment syndrome

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Introduction

High-pressure injection (HPI) injuries of the hand and upper extremity are relatively rare diagnosed but true surgical emergencies. They are caused by high-pressure guns emitting jet streams at high pressures (exceeding hundreds of atmospheres); at these pressure levels, the injected material is forced through minimally distensible structures of the hand and fingers, spreading along the fascia, tendon sheath and neurovascular bundles with significant destructive consequences [1]. Rees first reported in 1937 that the gas detected in the soft tissues could develop secondary to high-pressure injection injuries [2]. Subsequently, it has been reported that this may be due to not only gases but also a variety of liquids such as pressurized paint, grease, diesel fuel, helium, carbon dioxide and nitrous oxide [3].

The injected material has deleterious effects in several ways including a direct toxic effect of the involved chemical, ischemia, high-velocity mechanical impact, secondary infection, a significant rise of pressure in the closed palmar or digital space with consequent compartment syndrome [4]. Despite the non-toxicity of injected air, the importance of acute surgical intervention must be emphasized, as there is a risk of high-pressure soft tissue damage.

No case of air injection resulting in amputation has been reported, even though most of these injuries were treated non-surgically with intravenous antibiotics and observation. Although these patients routinely have a favorable prognosis, there are cases of long-term peripheral neurologic dysfunction and infection [5]. An adequate history of the operating pressure, the time of the injury, and the volume and contents of the injected materials may assist in making the diagnosis and prognosis [6].

In this case, we present a case of subcutaneous emphysema and clinical signs and symptoms of compartment syndrome resulting from an absorbing wound due to High-pressure injection (HPI) injuries that occurs at the upper extremity after the pressure balloon machine blowing accident.

Case Report

A 35-year-old man was admitted to the emergency room with complaints of severe pain and swelling in the hand and forearm, exacerbated by any active movement. Patient's history revealed that he was working in a balloon inflating workshop where the pressurized gas pump explosion hurt the right hand of the patient. His vital signs were as follows: blood pressure 120/75 mm Hg, pulse rate 86 beats/min, respiratory rate 19 breaths/min, and SpO₂ 98% by pulse oximeter on room air. He had no past medical history or medication.

On physical examination, there was swelling and paleness over the pulp of his right thumb with a 0.5 cm sucking wound on the ulnar side. On palpation, the skin was tender and tense; also crepitation was evident (Figure 1). Neurovascular examination revealed numbness over the pale area of the pulp, and capillary refill was absent. On radiological examination, subcutaneous emphysema and diffuse gas were observed in the pulp of the right thumb extending beyond the wrist to the forearm with a fracture in the proximal phalanx (Figure 2).

Based on the physical examination findings, coldness and numbness on the thumb, compartment syndrome was considered and aspiration was performed using an 18 G injector. After the procedure, subcutaneous emphysema was minimized and the upper limb of the patient recovered from the symptoms. Tetanus immunization was given. Although there was no clinical suspicion of infection, prophylactic antibiotics were administered and the patient was observed for 24 hours in the ED due to concerns about the progression of compartment syndrome. He was discharged the next day. At the final followup one week after the injury, the emphysema resolved, the wound healed and there were no signs of infection or functional deficit.

Discussion

HPI injuries have an incidence of 1 in 600 hand trauma cases and are predominantly occupational injuries, usually occurring in men. HPI injuries occur mainly in hands and fingers. The thumb and first two fingers are those most likely to be injured [7].

Air trapped in the subcutaneous tissues can occur in due to trauma or surgical dissection, generation of gas by chemicals (hydrogen peroxide) introduced into the wound, accidental injection of compressed air, a football inflation pump, scuba diving equipment, a mishap during blood donation, factitious manipulations related to Munchausen syndrome and air introduced into the deeper tissues as a result of air trapping by valve like wound edges or as a result of high pressure water injection or improper irrigation [8-10].

High pressure guns emit jet streams at pressures of thousands of pounds per square inch (psi). An HPI injury, between 2000 psi and 10,000 psi, may result in tissue damage, muscle destruc-

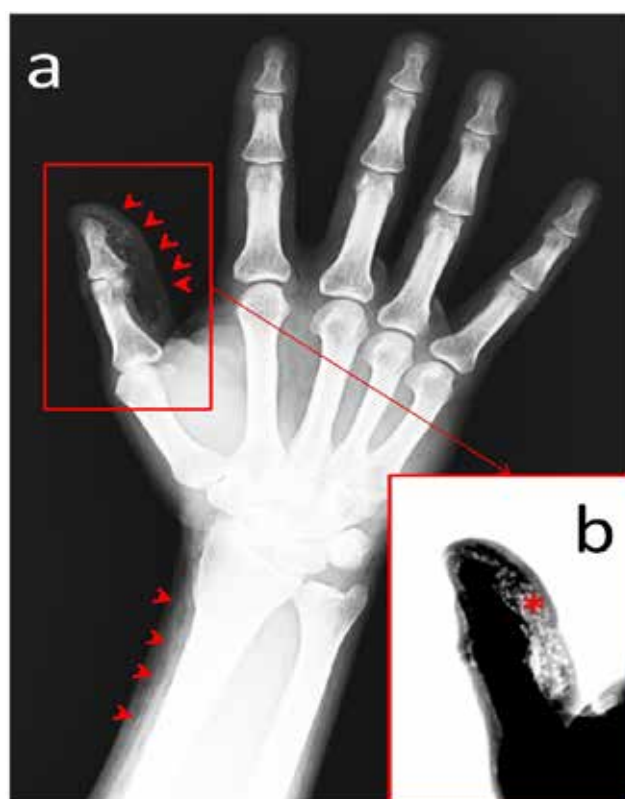


Figure 1. Anteroposterior view of the right upper extremity demonstrating subcutaneous air in the pulp of the thumb, and hand extending beyond the wrist (red arrows) to the forearm.

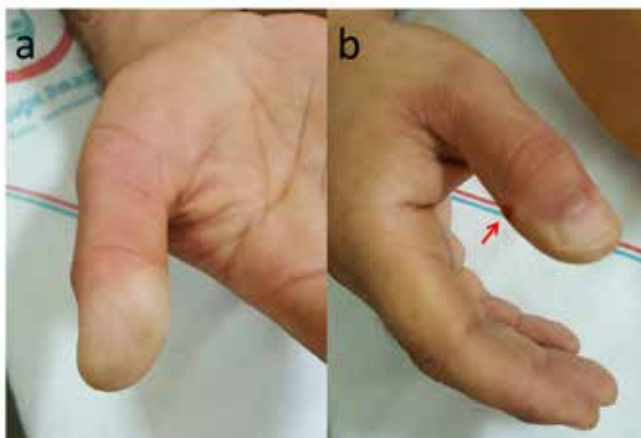


Figure 2. Clinical appearance of the patient's thumb. There was a 0.5 cm sucking wound (red arrow) and paleness in the pulp of the right thumb.

tion, and tearing of blood vessels underneath the skin, but with nothing more than a small innocuous wound visible at the point of entry. It is easy to underestimate the subcutaneous damage and infectious complications due to its deceptive appearance [11].

A small hand or wrist laceration or puncture wound can lead to crepitus by serving as a oneway valve for airflow into the soft tissues [12]. In the presence of a web space puncture wound, for example, digital abduction and adduction produce negative pressure, drawing air into the subcutaneous space; the air is then trapped as the wound collapses. Repetitive motion can thus lead to progressive subcutaneous air accumulation and such injuries have been referred to as “sucking wounds” of the limbs [13,14]. Our patient also had a slight laceration of his thumb and thought that the pressurized air was entering at that part.

Depending on the volume and materials injected, the finger may be distended, swollen, and tender on palpation. If vessels in the involved digit have been thrombosed or compressed, the digit may be pale, anesthetic, or even ischemic [4]. In the case of an air injection injury, associated crepitus and subcutaneous emphysema are possible [7].

Clinically, the injury presents with a benign appearing wound, as demonstrated in our case, which can often mislead the examining physician and cause a delay in the appropriate treatment. History of injection of any material under high pressure should prompt the emergency or primary healthcare professional to seek urgent expert surgical opinion. A detailed history of the mechanism should be taken focusing on the time of the injury, volume, nature of the material and an estimation of ejection pressure [6].

Following a physical examination of the involved upper extremity that notes circulation in the digit and evaluates for compartment syndrome, further investigations, such as radiographs, may be helpful. Plain radiographs can be rapidly obtained. In noninfectious cases, air is seen to respect the tissue planes [8]. In our patient, gas accumulation was observed only within the subcutaneous tissues just under the skin. There was no penetration into muscle tissues.

Morbidity depends largely on the materials injected. Paint sol-

vents seem to cause the greatest damage and result in amputation in 60–80% of cases, whereas injuries from air and water can be managed conservatively with close observation especially serial examinations, limb elevation to reduce swelling, immobilization to prevent further air entry and symptomatic treatment along with prophylactic administration of antibiotics and generally have a good prognosis [14]. Furthermore, if the gas accumulation can be localized, as in our case, aspiration may be a good option for relief of pressure and provides circulation [8,13]

HPI injuries to the digit usually present as a small benign wound which often masks the severe underlying trauma. Emergency physicians must be aware of the varied and deceptive presentations, and subsequent complications, to deal with injuries effectively.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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